A Simulation of Evolved Autotrophic Reproduction

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ABSTRACT
In this experiment we evolve reproductive behaviors for a simulated vehicle. Future work will employ the resulting behaviors to populate a simulated ecosystem.

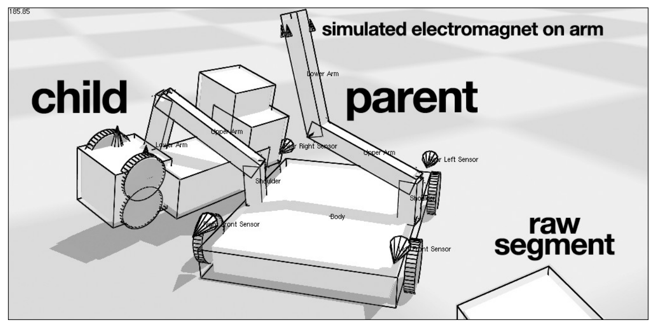
Categories and Subject Descriptors
I.2.0 [**Artificial Intelligence**] General—*Cognitive simulation;*
I.2.6 [**Artificial Intelligence**] Learning—*Connectionism and neural nets*;
I.2.9 [**Artificial Intelligence**] Robotics—*Autonomous vehicles*;

General Terms
Algorithms, Experimentation

Keywords
Self-replication, Neuroevolution, Robotic Control

1. INTRODUCTION
Autotrophy is the capability of self-nourishment, which in von Neumann's space exploration scenario [1] would be demonstrated by agents using local material and information for replication, fuel, navigation, etc. This experiment is based on the hope that we will eventually be able to use the demands and process of autotrophic reproduction to select the characteristics intelligence and creativity. We assume that it is easier and more effective to generate synthetic intelligence by reapplying the pressures that lead to human intelligence to evolving artifacts than it would be to attempt to define and design an embedded synthetic intelligence. Furthermore, by utilizing and selectively constraining a rich, simulated scenario wherein robotic agents can exhibit creative expression through assembling and modifying their offspring, it may be possible to detect signs of synthetic intelligence, such as experimentation and design, using measures as simple as reproductive efficacy.

2. SIMULATIONS
This experiment allowed the possibility of a trial, or parent, vehicle resizing a component before or after the component is integrated into a second, or offspring, vehicle. We hope to evolve parental behaviors like recovery, resizing, and assembly. By allowing the variation of components found in the environment, a parent vehicle is allowed degrees of creative freedom. In the current experiment, fitness is an expression of strict reproductive fidelity (assessed by the sum of the dimensional differences, between parent and child, of the seven components) and the distances between the parent, child, and raw elements. It is hoped that the vehicle simulated in these experiments is, in a sense, representative of an autonomous robot that could convey "raw" stock, load and assemble machines, maintain, and otherwise expedite the duplication of a system composed of a conventional machine shop and the mobile robot itself.



Trial vehicle with partially assembled child.

Fully connected artificial neural networks control the trial vehicles. Sensors deliver signals to 41 of the nodes, and 16 are tied to effectors, leaving 319 nodes without dedicated functional roles. We improve our population with a steady-state tournament style genetic algorithm—randomly selecting four neural networks from a population, running trials of all four, and finally replacing the two lowest scoring individuals with new neural networks. Replacement networks are produced using two-point crossover from the two highest scoring individuals with 10% of the weight values replaced by novel mutations.

3. RESULTS
We confirm the possibility of evolving reproductive behaviors for this scenario using a *t*-test of two samples of fitness values consisting of the first 100 trials (x1) and the last 100 trials (x2) of a run of 16,400 trials.

	Mean	St. Dev.	SE Mean
x1	932	301	30
x2	1787	729	73

Difference = mu (x1) – mu (x2)
Estimate for difference: -855.398
90% lower bound for difference: -957.020
T-Test of difference = 0 (vs >):
T-Value = -10.84, P-Value = 1.000, DF = 131

4. REFERENCE
[1] Freitas, R. A., Jr. and Merkle, R. C. *Kinematic Self-Replicating Machines.* Landes Bioscience, Georgetown, TX, 2004.

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